Cosmic-ray muon technology to be used to image debris inside Fukushima Dai-ichi reactors

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Measurement Device

Toshiba Corporation and the International Research Institute for Nuclear Decommissioning (IRID) today announced the development of a muon-based technology for imaging and mapping nuclear fuel debris inside the reactor pressure vessel (RPV) of the Fukushima Dai-ichi Nuclear Power Plant. The system was developed as the part of sub-project for "Development of Fuel Debris Sensing Technology for Nuclear Reactors" financed by the Agency for Natural Resources and Energy.

Dismantling the tsunami-damaged reactors at Fukushima Dai-ichi can be speeded up if the recovery team has a realistic estimate of the damage and the location of nuclear fuel debris in the core. In the case of Three Mile Island, it took 10 years before this could be assessed. At Fukushima, measurement of cosmic-ray muons seemed to offer a way forward, but imaging resolutions achieved with conventional methods are not sufficient to identify debris in the RPV.

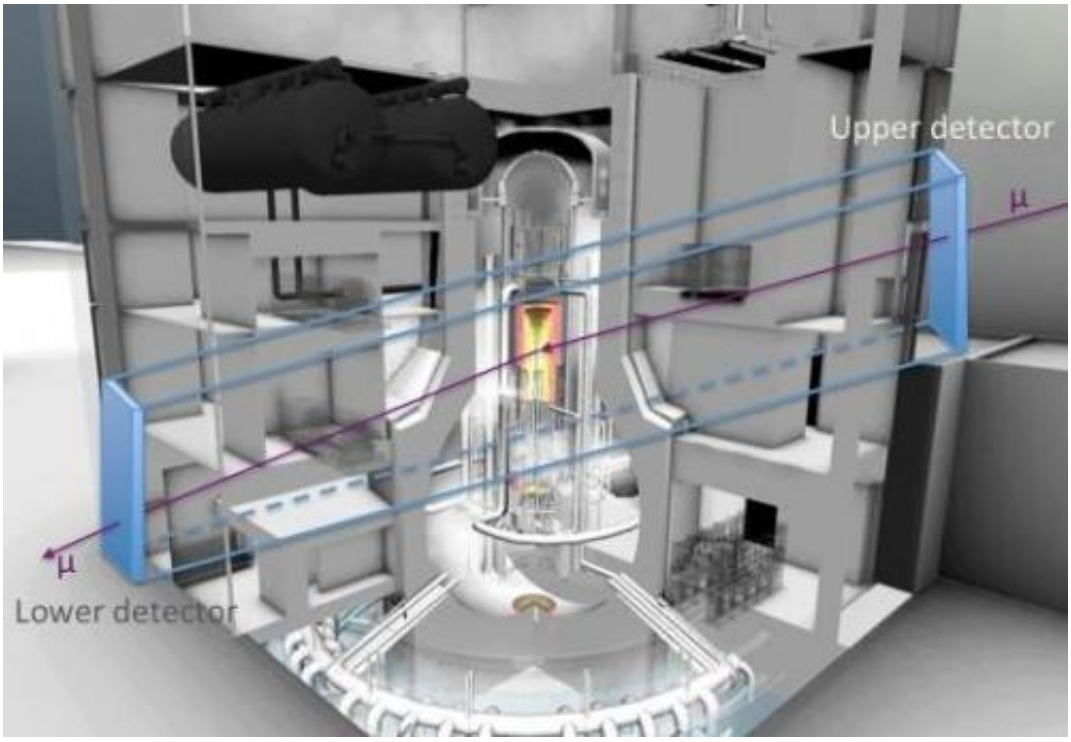
The solution developed by Toshiba and IRID successfully measures the scattering of cosmic-ray muons before and after they pass through the reactor core. Technical evaluations and simulations have confirmed that actual measurements using muon trackers can image debris as small as 30-cm in size. Imaging at Fukushima Dai-ichi Unit 2 will start within FY2015, after completion of final testing and installation.

The high penetrative power of naturally occurring cosmic-ray muons has long been known, and their use in obtaining density maps has been demonstrated with objects as diverse as Egypt's pyramids, a temple gate and the interior of volcanoes. However, standard muon transmission methods cannot be used at Fukushima as the rays are scattered too much by the thick concrete and steel walls of the RPV. It is impossible to distinguish between uranium and water in the core.

Toshiba and IRID have adapted a novel technology for measuring the scattering behavior of muons penetrating objects, building on techniques originally developed by the Los Alamos National Laboratory (LANL) in the United States. Two external detectors are placed in parallel to one another on opposite sides of the reactor building, and cosmic-ray muon trajectories, scatter and scatter angle are recorded. The scatter angle is directly related to the atomic number of objects the muons collide with, and uranium can be distinguished from surrounding structural objects with lower atomic numbers.

Toshiba has enhanced the detection process to the point where RPV fuel debris as small as 30cm can be imaged, by developing an electric circuit and algorithms that remove gamma-ray noise from the high radiation background at Fukushima. By combining Toshiba's gamma-ray noise removal technology, which has been accumulated through development of measurement instruments for inside the reactors, with the muon-scattering method developed by LANL, the collaboration, started in 2013, will be put to practical use for Fukushima Dai-ichi.

Mamoru Hatazawa, Vice President of Toshiba Corporation Power Systems Company said, "All of us at Toshiba are pleased to have worked with LANL on development of this technology. We are confident that it will prove to be a useful tool for analyzing the interior of the RPV, pinpointing the locations of fuel debris, and pointing the way forward in the decommissioning of Fukushima Dai-ichi. We also hope that this innovative approach will find applications in other areas".



Duncan McBranch, the Chief Technology Officer of LANL said, "This collaboration has helped to demonstrate an important new technique for mapping nuclear facilities. Thanks to the partnership between Japan and the US Department of Energy, and to our collaborators at Toshiba and IRID, we have scaled up a technique that was originally developed for detecting nuclear materials in shipping containers. We are hopeful that this collaboration can accelerate the remediation work at Fukushima Dai-ichi".

The detection technology will not only help to locate the debris, but provide essential data for selection of efficient fuel removal method and for designing extraction equipment at an early date. Toshiba and IRID will continue to contribute to R&D supporting the decommissioning of Fukushima Dai-ichi.

Provided by Toshiba Corporation

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